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ABSTRACT

A meta-analysis of 35 interventions to reduce diagnostic testing revealed that testing was reduced overall by 17.6%. Stronger effects were found for immediate reductions (31.7%) compared to reduction at follow-up times (18.7%) and stronger effects were found for interventions targeted at specific tests (23.2%) compared to interventions designed to reduce testing in general (11.8%). An examination of the quality of needs assessment shows that interventions planned on the basis of careful analysis of need were more effective than those based on the innovators' intuitive impressions. The value of the use of learning theory in developing effective interventions is discussed. The contrast between the cognitive processes of experts compared to the processes of less experienced decision makers reveals that many interventions may not be conducive to helping medical residents develop their skills in diagnostic testing in the most efficient manner. Several innovative, on-line interventions are described, which include effective interventions that may have lasting impacts since they seem to be based on processes leading to effective learning. One table and one graph are included. (Author/SLD)

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If You Don't Know Why a Problem Occurs, Can Effective Interventions Be Developed?

Reducing Medical Diagnostic Testing

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Abstract

A meta-analysis of 35 interventions to reduce diagnostic testing revealed that testing was reduced by 17.6%. Stronger effects were found for immediate reductions (31.7%) compared to reductions at follow-up times (18.7% reduction) and stronger effects were found for interventions targeted at specific tests (23.2%) compared to interventions designed to reduce testing in general (11.8%). An examination of the quality of needs assessment showed that interventions planned on the basis of careful analyses of need were more effective than those based on the innovators' intuitive impressions. The value of the use of learning theory in developing effective interventions was discussed. The contrast between the cognitive processes of experts compared to the processes of less experienced decision makers revealed that many interventions many not be conducive to helping medical residents develop their skills in diagnostic testing in the most efficient manner. Several innovative, on-line interventions were described that include effective interventions which may have lasting impacts since they seem to are based on processes leading to effective learning.

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If You Don't Know Why a Problem Occurs, Can Effective Interventions Be Developed?

Reducing Medical Diagnostic Testing[1]

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The problem of excessive diagnostic testing, particularly on the part of medical residents, first came to my (first author) attention when I participated in a study of the effect of converting a community hospital into a teaching hospital. One part of that study involving diagnostic test totals per month in the hospital; a smoothed version is in the handout. The graph was a surprise to us -- it shows a clear sizable jump in the total number of tests in the hospital. You can see the jump of about 16% in the very month residents began to provide direct care on about two-thirds of the units. If the other third of the units had residents also, it appears that an increase of 24% would have been observed.

Even if we evaluators did not know about the issue, the hospital physicians in charge of the residency should have expected this since over-testing was discussed in the literature on medical education even in 1974. Nevertheless, the administrators of the educational program denied that residents ordered more tests than attending physicians, a number of interventions to lower the rate at which residents order diagnostic tests have been discussed in the medical education literature.

Such interventions seem to have become more popular as the costs of medical care including diagnostic testing have increased and increasingly have become a political issue. One purpose of this study was to learn to what degree these interventions have been

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successful. A second purpose was to learn how intervention developers went about planning the interventions. According to evaluation theorists, program developers should assess the need for an intervention, use some conceptual foundation to design the intervention, monitor implementation, and assess both impact and side effects. I am aware of meta-analyses in which the quality of the research design has been related to the impact of the intervention, but I am not aware of a study relating the quality of intervention planning to the impacts of programs.

The studies. We gathered 35 published reports of interventions to reduce diagnostic testing; these reports described 49 interventions, but two were discarded as inappropriate. Characteristics of the setting, the target professionals, the design, and the intervention were recorded. The dependent variables were number of tests ordered or costs of tests per patient. Since these were ratio scales, our measure of effect was percentage reduction in testing. In addition we recorded the attention innovators paid to (a) the actual degree of over-testing in their own facilities, (b) the conceptual bases for their interventions, and (c) possible side effects.

Some practical problems. Before describing the findings, it is important to note that there are some real ambiguities in research on reducing the rate of testing. Unless the patient is on Medicare, physicians and hospitals are reimbursed for doing procedures and tests, not for carrying out efficient medical care. Simply lowering the rate of testing will mean less revenue for hospitals. Even worse, if fewer tests are done while laboratories and lab personnel are maintained in the hospital, reduced testing will mean lower charges to insurance companies but essentially the same cost to the hospital. One intervention-developer thanked the administration for supporting the research even though an effective intervention would

have cost the hospital revenue.

With reimbursement for Medicare patients now being set on the basis of Diagnostic Related Groups, it is indeed in the hospitals' financial interests to carry out only necessary diagnostic tests. Until reimbursement policies of private agencies cease encouraging excessive testing, hospitals will be tempted both to test excessively and to limit attempts to reduce testing.

Findings

The overall percentage reduction across the interventions was 17.6%. Most interventions were evaluated soon after the interventions ended; however, the effects of eight interventions were examined after the intervention ended. Mean immediate effect was a 31.7% reduction while the mean reduction at the follow-up -- an average of six months later -- was 18.7%. Some interventions were aimed at reducing specific tests, others at diagnostic tests in general. Those prepared for specific tests were twice as effective as those aimed at testing in general, 23.2% versus 11.8% ($p < .02$).

Effects of the interventions were related to a number of characteristics of the studies. Table 1 includes the mean reductions related to attention to careful planning. In general, the more care in planning indicated by the authors, the more effective the interventions were. The marked exception was the discussion of reasons over-testing; there may be some coincidences that led to this surprise which we discuss in the full draft paper. The other surprise was that explicit attention to theory was not related effectiveness. But attention to measuring need before the implementation of the program and to side effects after implementation were all related to more effective programs.

Discussion

Typical interventions and test-ordering decisions

The prototypal intervention described in these reports is based on these change strategies: residents should learn more facts to make better choices in test ordering, residents are told that the supervisors of residency education will be watching their test ordering rates which are too high, and the rate of test ordering of each resident will be compared to those of other residents. It seems that the implicit assumption is that residents could do a more efficient job if they would just put their minds to it. Taylor's work (1992) suggests that assigning extra readings to residents regarding the use of diagnostic tests may not be effective; Taylor found that second year medical students report not reading much of all assigned readings. Moreover, residents have such demanding schedules that one former resident said that she learned how to "nap" between heart beats while listening to the hearts of patients (Harrison, 1982).

What the programs ought to do

Experienced physicians test less than residents. The goal is to get residents to be like experienced physicians. How to achieve that is not necessarily obvious. The reflexive response by medical educators is to get the residents to know more and to make better decisions. Schmidt, Norman, and Boshuizen (1990) write that new residents depend on a different approach to gathering information for making diagnoses than experienced physicians do. Schmidt *et al.* seem to suggest that residents seek to follow the careful procedures described in books on medical decision making (for example, Ridderikhoff, 1989; Sox, Blatt, Higgins, & Martin, 1988). It seems that typical interventions seek to strengthen what residents are already trying to do. But Schmidt and colleagues suggests that experts do not

work that way.

Experienced physicians use "illness scripts" based on their memory of illnesses, patient characteristics, and outcomes while residents depend on knowledge of pathophysiological, causal models of disease entities in making decisions. Experts do less and arrive at decisions more quickly than novices. In fact, "... most of the time most experts never do problem solving ..." (Schmidt *et al.*, 1990, p. 619). It isn't clear that experts know just how they go about making diagnoses. Norman *et al.* (1985) found that experienced physicians treating actual patients in their own practices used approximately half of the tests they recommended to be used with simulated patients. In other words, when faced with an abstract task, the physicians used theoretical, book knowledge, but when faced with real patients, they depended on their extensive memory of patients and used "illness scripts" to make their decisions.

If Schmidt *et al.* are correct, then interventions that focus the resident on additional medical knowledge about tests or informing the resident about excessive testing are not likely to help residents to become more like experienced physicians even if the immediate result of the interventions is a moderate reduction in the use of tests. Such interventions will yield only marginal improvements in performance because they are not based on the actual process used by experienced physicians in selecting tests to order. Instead of asking residents to work even harder, it would be best to try to help them develop better ways of making diagnostic test choices.

Toward more effective interventions. Interventions should be planned to help the resident become like a experienced physician as quickly and as efficiently as possible. Learning theory suggests that learning is best when feedback comes close in time to the

behavior that one wants to change rather than coming at some other time. A second concern is that the intervention must not raise the cost of medical education even more. Popular, but expensive, interventions utilize chart reviews by medical school faculty; such interventions can contribute to medical education, but cannot be maintained as a routine part of residency training because they are both expensive and tedious.

If teaching additional facts to residents doesn't work and if watching their every move is too expensive what can be done? Less expensive and clinically educational interventions have been described by Tierney and his colleagues (1987, 1988). In a series of papers they describe interventions delivered through computer terminals which physicians already use to order tests. After entering a test and the instructions to the laboratory about what disease is to be ruled out by the test, a window appears in the screen giving the physician -- usually a resident -- information on that test based on previous testing or on the probability of the test ordered achieving the resident's goal. Unnecessary tests are those that have little pay-off in planning the patient's treatment; low probabilities may mean that the test is not needed at this time. After getting the feedback, the resident may cancel the order or indicate that the test is to be done.[2]

What we are suggesting is that most interventions are interesting demonstrations that diagnostic testing can be lowered, but that the interventions are not planned to change the residents' practice in an effective manner. They are marginally effective because they ignore psychological principles of effective learning or they are too expensive to continue. If more

[2] It is hard to compare the level of effect of Tierney's interventions with that of others because patients, not physicians were randomly assigned to treatment and control groups. Thus, the same physicians formed the experimental and the control groups. It seems reasonable to suspect that what physicians learned when selecting tests for experimental patients could have effected what they did when selecting tests for control patients even if only to a lessor degree.

careful analyses of the problems and the effectiveness of change strategies had been considered, such weaknesses may have been detected. For example, a comparison between the cost of the program and the likely impact on testing could have been compared. Or, if the assignment of extra readings and seminars had been considered in the context of the residents' responsibilities, it might have been clear that it would be hard to change the residents using that strategy. Furthermore, interventions ought to contribute to the development of physicians rather than to force even more effort from overworked residents.

There is one more wrinkle that is suggested by Tierney's on-line interventions: the on-line interventions also influenced the testing decisions of faculty members. This suggests that not only does experience permit physicians to reduce testing, but that even experienced physicians can benefit from on-line information. Could one wonder that the real problem of over-testing is the inability of even gifted physicians to recall all the information that would be useful in selecting diagnostic tests efficiently? Which brings us back to the beginning: interventions will be more successful if the innovator knows what the problem really is.

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Table 1

Percentage Reduction Related to Indices of Careful Planning of Interventions

Variable	% Reduction	t	p	d
Extent of overuse measured				
Yes (n = 25)	21.57%			
No (n = 22)	13.17%	1.87	<.05	.55
Reasons for overuse measured empirically				
Yes (n = 4)	40.74%			
No (n = 43)	15.49%	3.40	<.01	1.74
Reasons for overuse discussed (If the reasons were measured, this rating did not apply.)				
Yes (n = 26)	10.92%			
No (n = 15)	22.51%	2.63	<.01	.85
Theory used in designing change strategy				
Yes (n = 14)	17.50%			
No (n = 32)	17.82%	.06	ns	-.02
Negative side effects considered				
Yes (n = 20)	25.02%			
No (n = 23)	12.64%	3.18	<.01	.97
Data gathered to rule out negative side effects				
Yes (n = 8)	32.57%			
No (n = 33)	14.71%	3.01	<.01	1.19
Positive side effects considered				
Yes (n = 5)	27.04%			
No (n = 42)	16.52%	1.43	ns	.68

Note. Numbers of observations vary because the descriptions of some interventions were not sufficiently clear about what was done.

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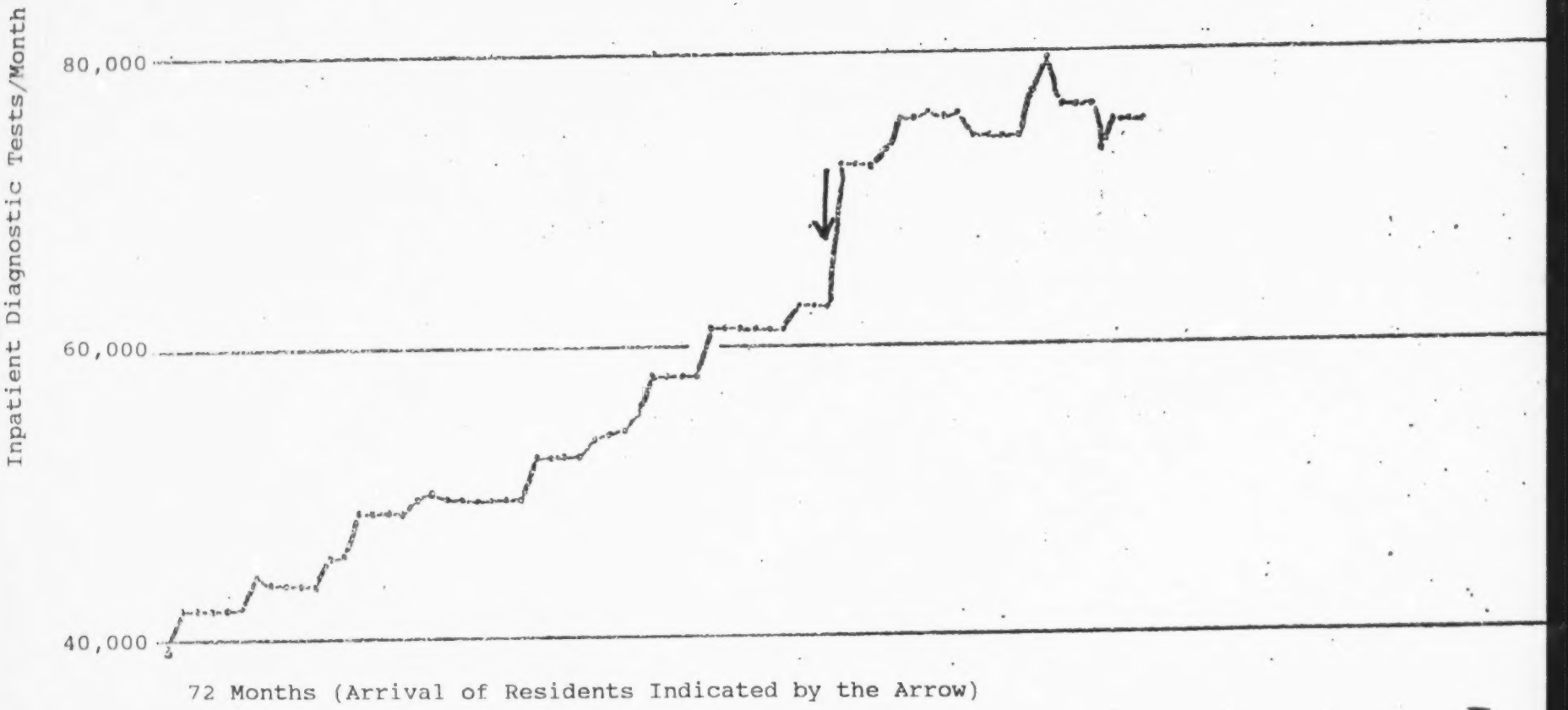
Inpatient Diagnostic Tests/Month
80,000
60,000
40,000
72 Months (Arrival of Residents Indicated by the Arrow)